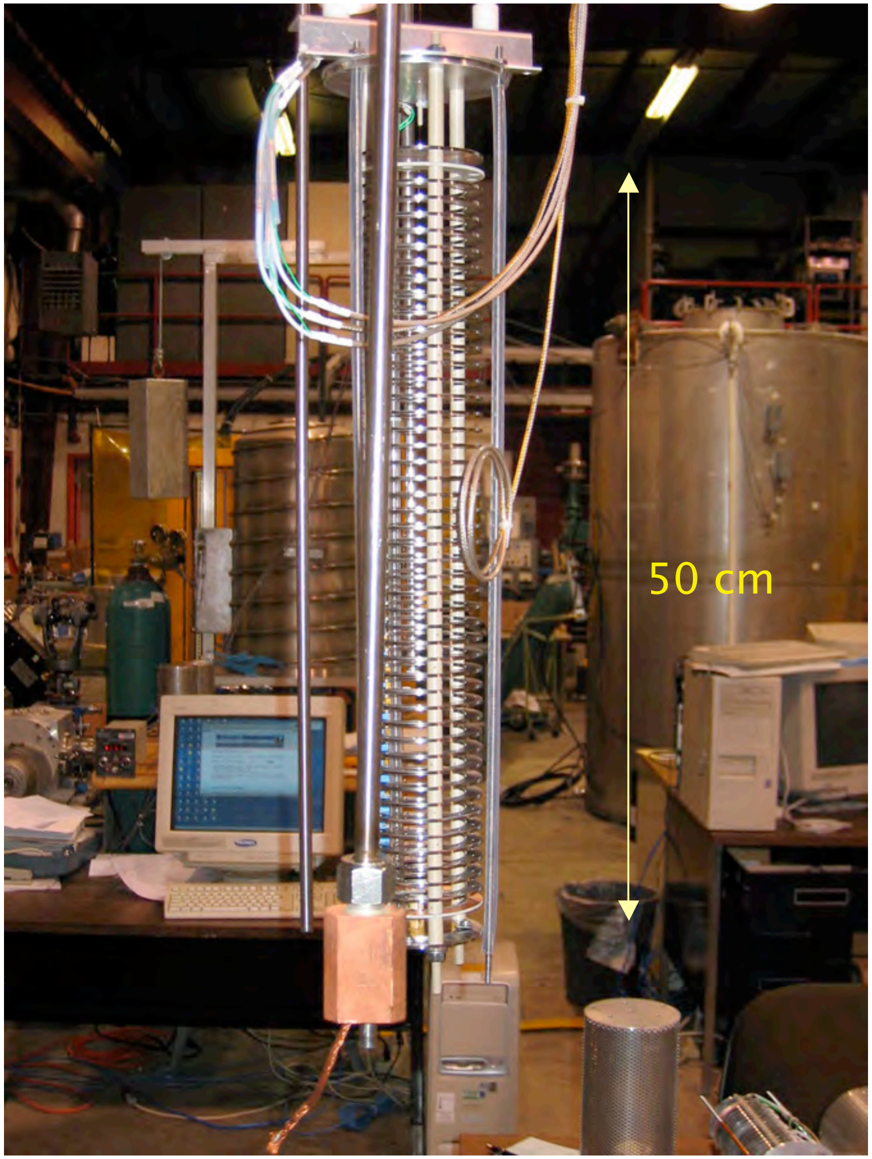
Purity Monitor – Description and Experience at Fermilab

Production of Clean Argon – Description of Filtering System and some anecdotes

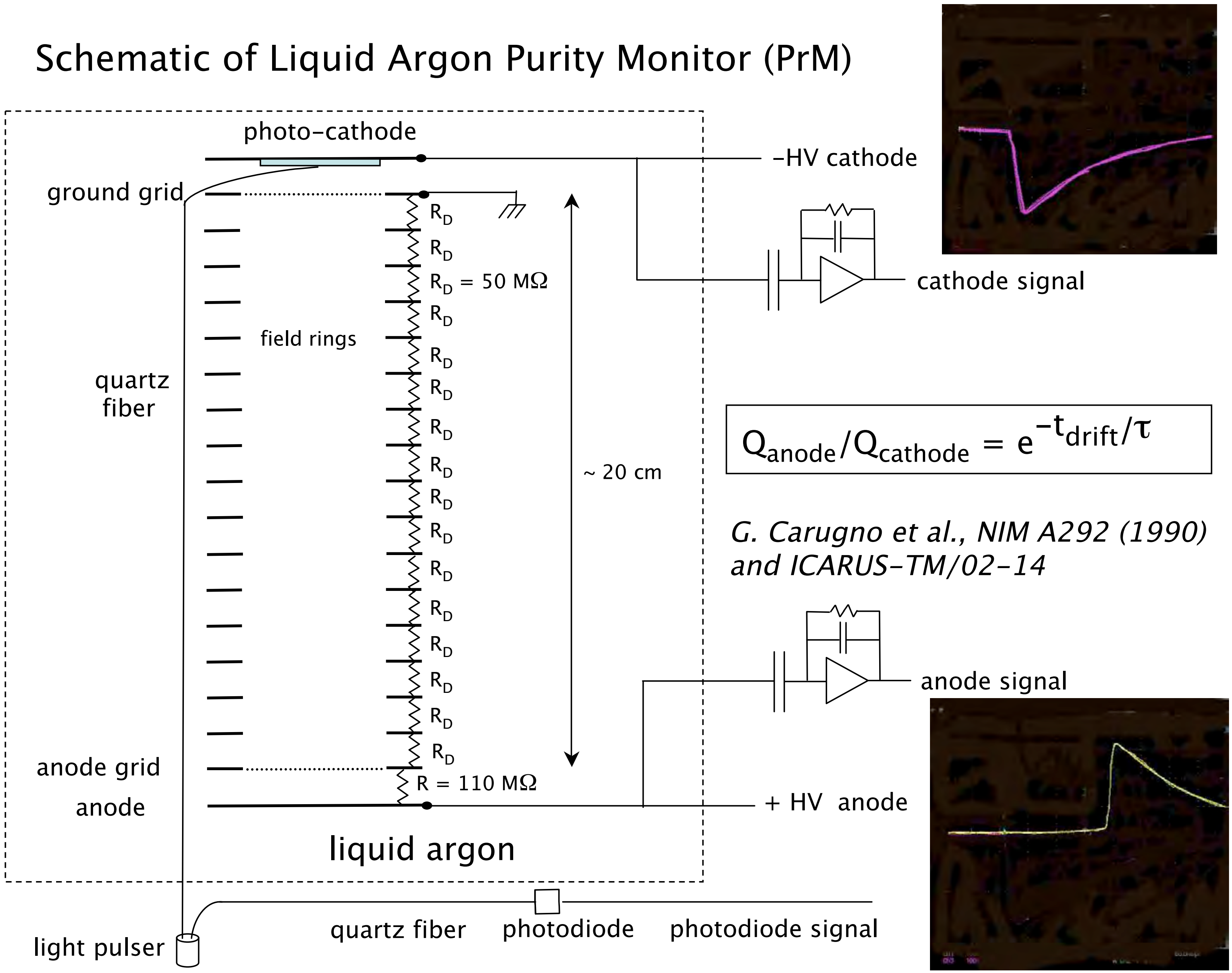
Lifetime Measurements

Next Step



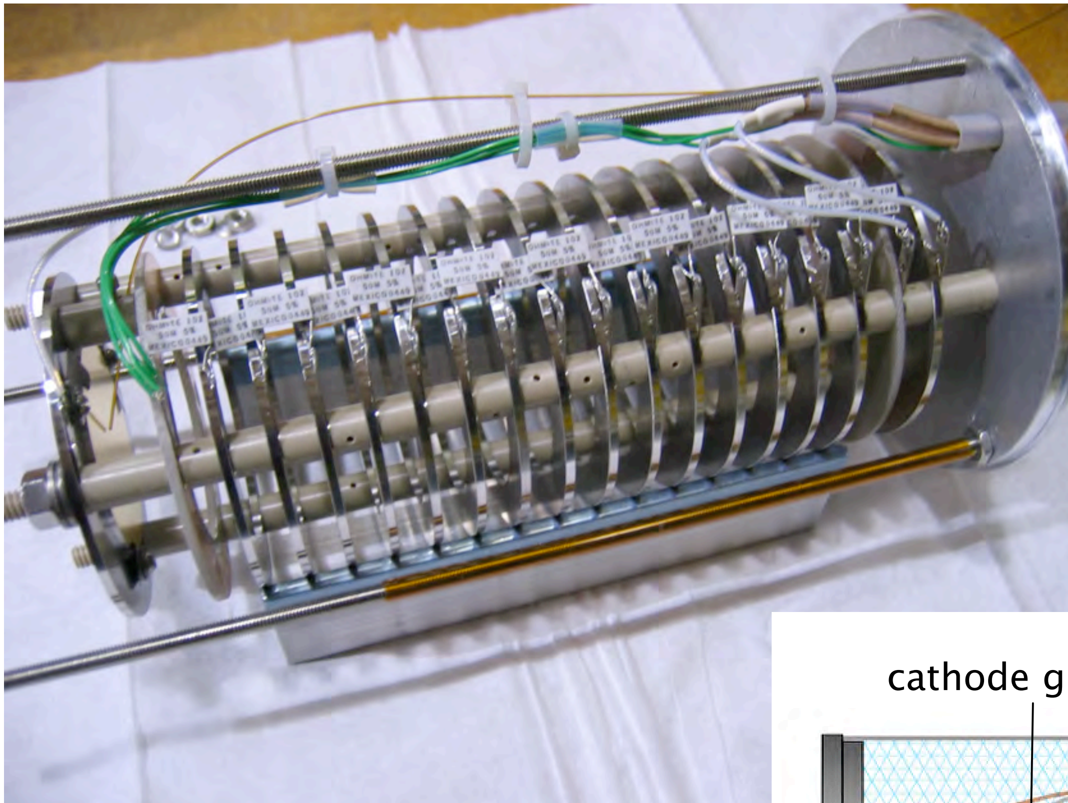
Now – that's a Purity Monitor

Schematic of Liquid Argon Purity Monitor (PrM)

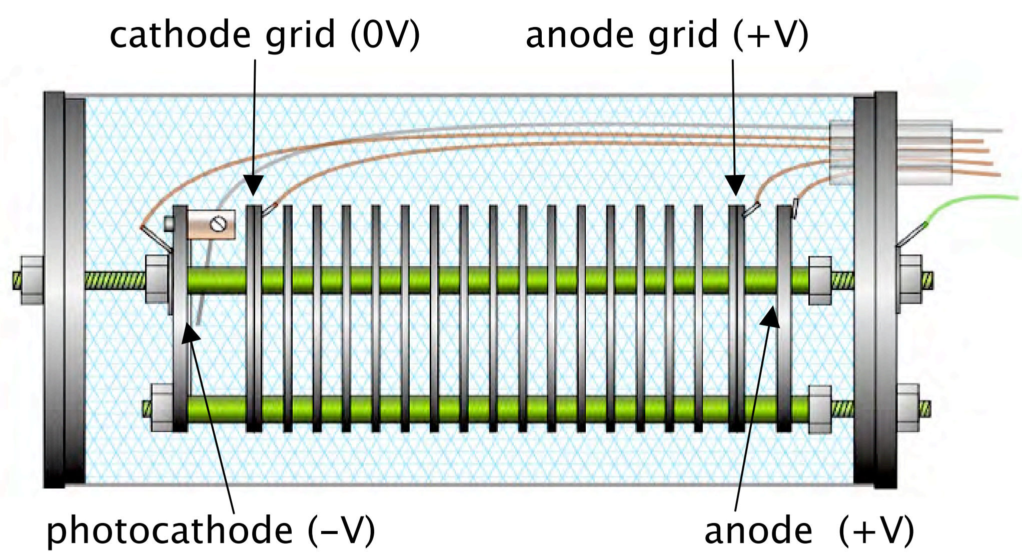


$$\boxed{Q_{anode}/Q_{cathode} = e^{-t_{drift}/\tau}}$$

G. Carugno et al., NIM A292 (1990) and ICARUS-TM/02-14



ICARUS clone made at FNAL



Long Purity Monitor – for long drift life times

Purity Monitor Hardware Interesting Aspects..

light system:

- Hamamatsu Xenon lamp - enough intensity - perhaps
- Oriel alternative - manufacturing problems, will need to work on suppressing electrical noise, not as stable pulse to pulse, more light, some nice features (adjustable rate and power)

light fiber:

- needs to be `non-solarizable' (UV damages fiber) (attenuation ~few db/meter when new, black after a few thousand pulses if not `n-s')

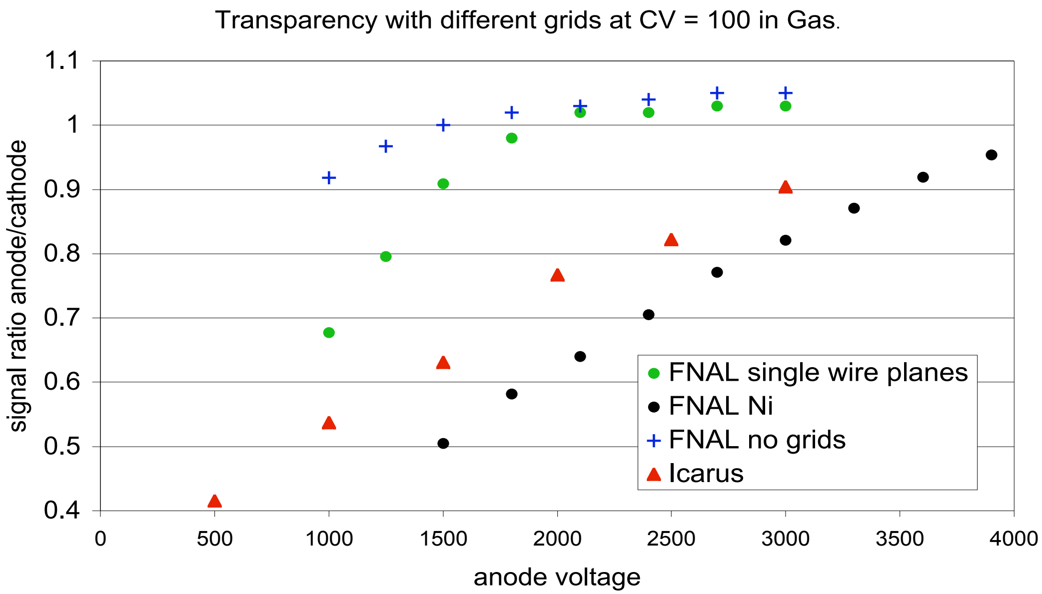
photo-cathode:

- investigated Gallium Arsenide, Gold and Nickel materials
- GaAs has largest initial yield but deteriorates in air (few days)
- Gold (evaporated on ?) is ~1/3 of GaAs yield and stable
- Nickel gives a signal (~1/3 Gold) - not pursued

cont:

grid issues:

the grids exist to define the signals induced on the photocathode as electrons leave and on the anode as they arrive – essentially an electron on one side of a grid is not seen by an electrode on the other. If any field lines end on the grid material, an electron travelling along those lines will end up on the grid.
The fields on either side of the grid need to satisfy ~ $E(d/s)/E(u/s) > (1+\rho)/(1-\rho)$; where ρ is the ratio of the perimeter of the grid material (wires or strips) to the pitch of the grid. If the field ratio does not satisfy this, the transmission through the grid falls rapidly. In practice, we could not procure appropriate grid material – so we make our own grids. It seems that we need higher field ratios than `predicted'.



`transparency' = Q_A / Q_B

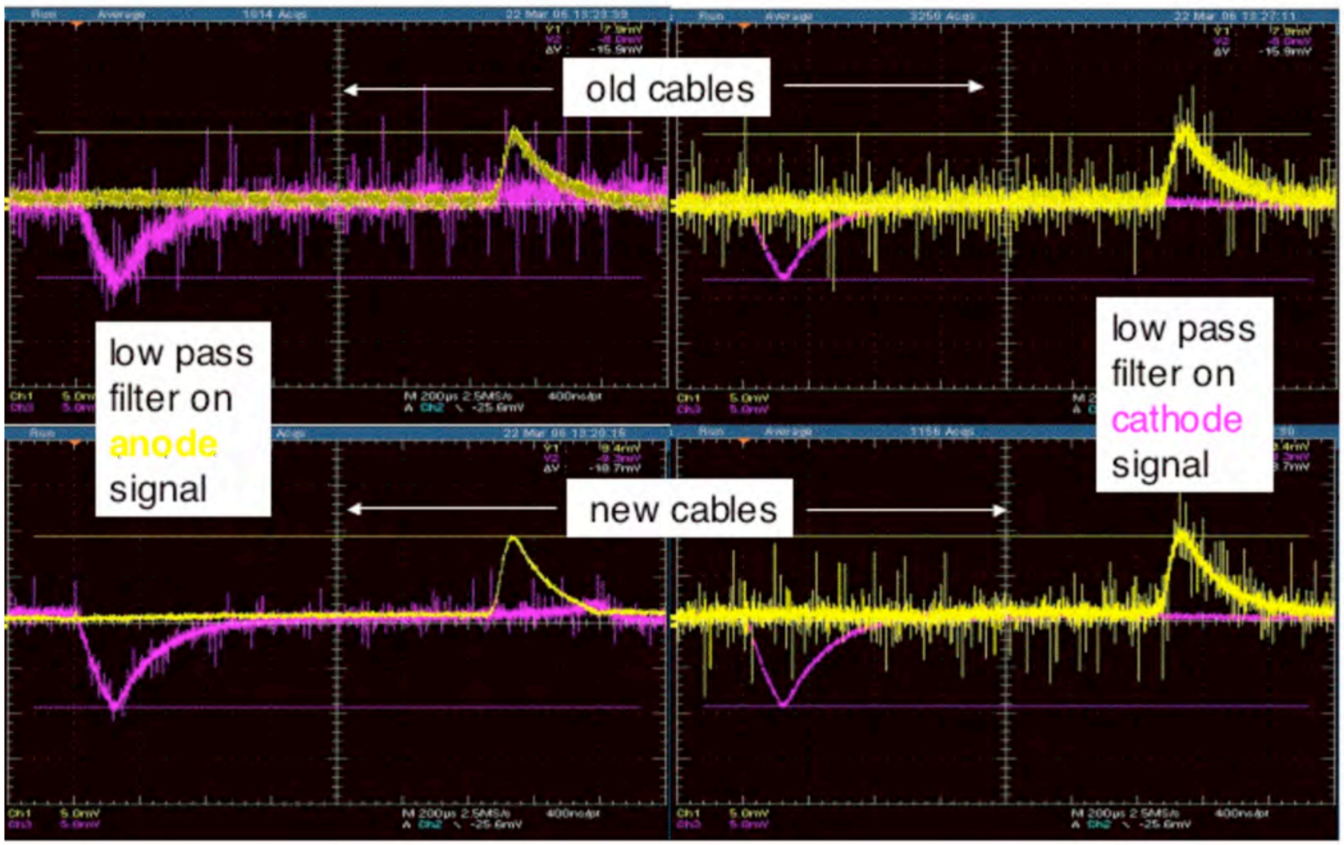
showing the effect on transparency of grids made with different size material

a(pred) = 1200
a(pred) = 1300
a(pred) = 2560

Electronics Issues

see docdb 32 by Walt Jaskierny for grounding, cabling, signal and ground feedthroughs, reduction of noise pickup from light pulser...an example of improvement going from RG58 to RG180 for signal cables

showing a) effect of simple low-pass filter and b) the effect of new cables; the effect of the new cables adds to the effect of the filter



3/22/06 2

Liquid Argon setup - Key Features: (see docdb under Terry Tope)

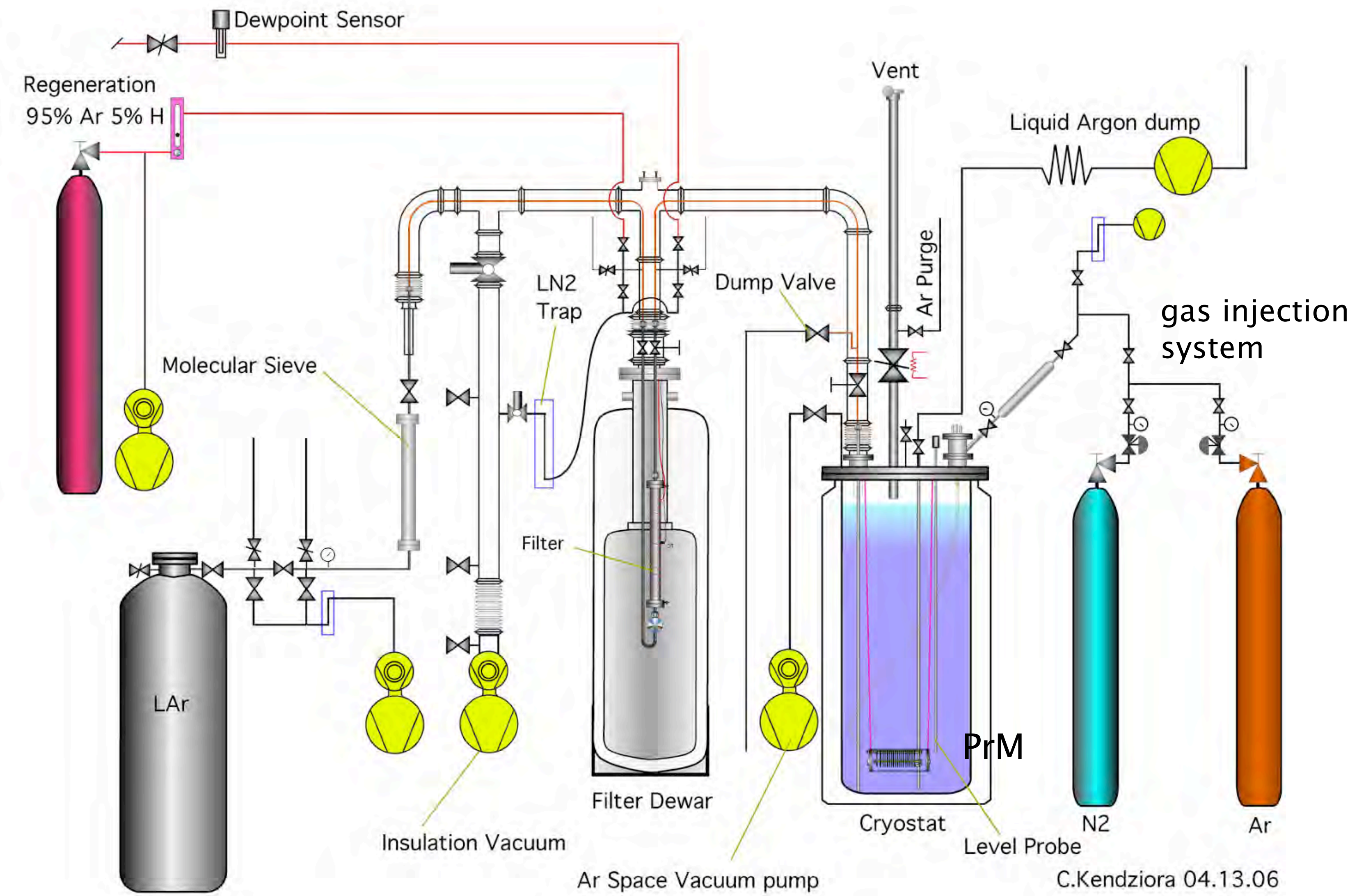
Single pass of liquid through molecular sieve and Oxygen filter -details of sieve and filter material in docdb document 91.
No filtering in test cryostat.
Test cryostat is evacuated to -6 range before filling.
Filter is available as raw material (Trigon) and has been regenerated in-house.
Obtain lifetimes in several milliseconds range repeatedly.

Anecdotes:

Water is a villain:-
System would not filter more than ~ 1/2 Argon dewar before we installed the molecular sieve; baking the filter restored its effectiveness.

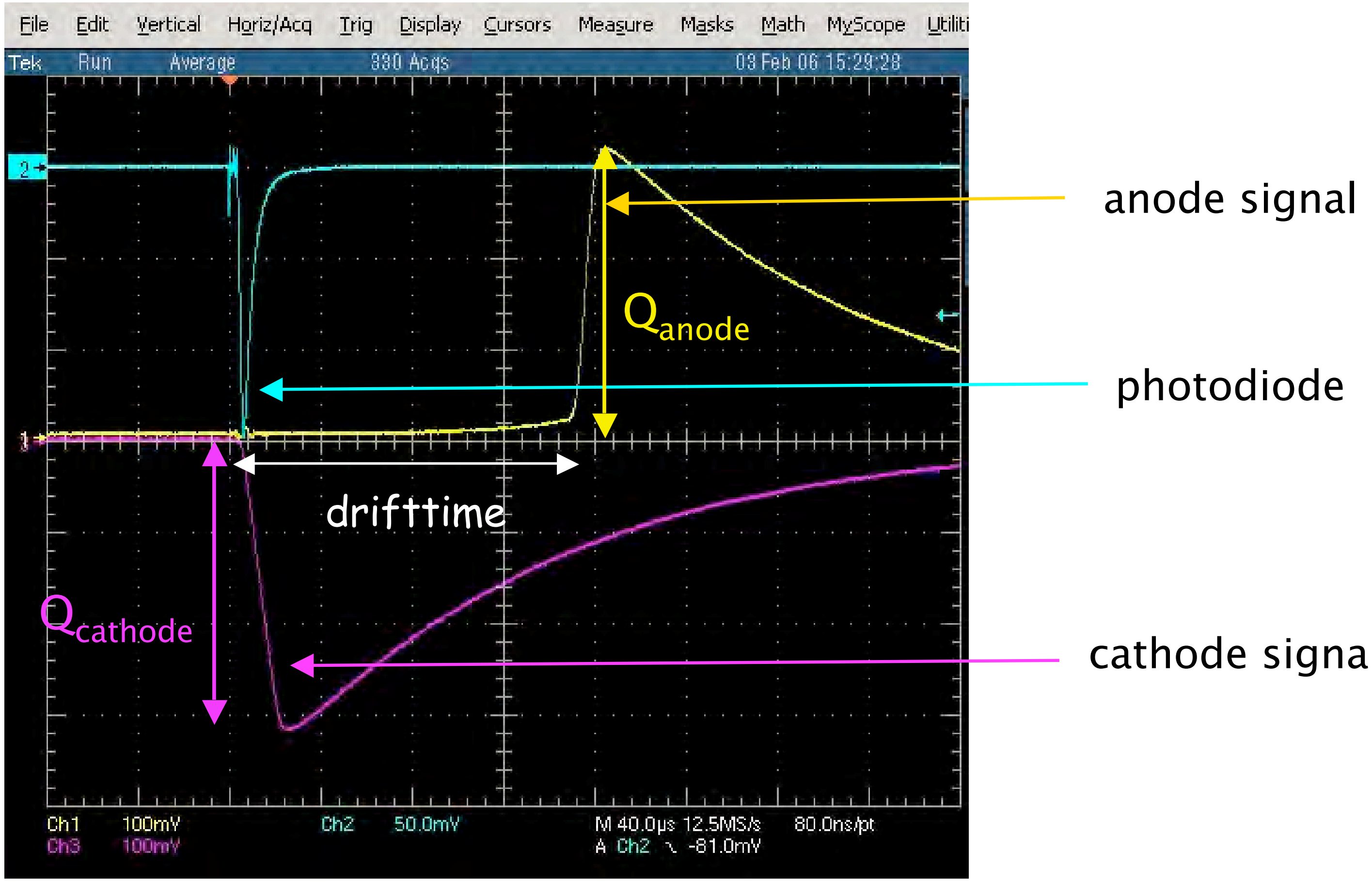
The filter releases oxygen when warm:-
Since we started diverting the first argon to pass through the filter and not allowing anything into the cryostat till there is liquid flow, we have not seen catastrophic loss of lifetime on resuming a fill.

Schematic of Liquid Argon setup at PAB (Proton Assembly Building)



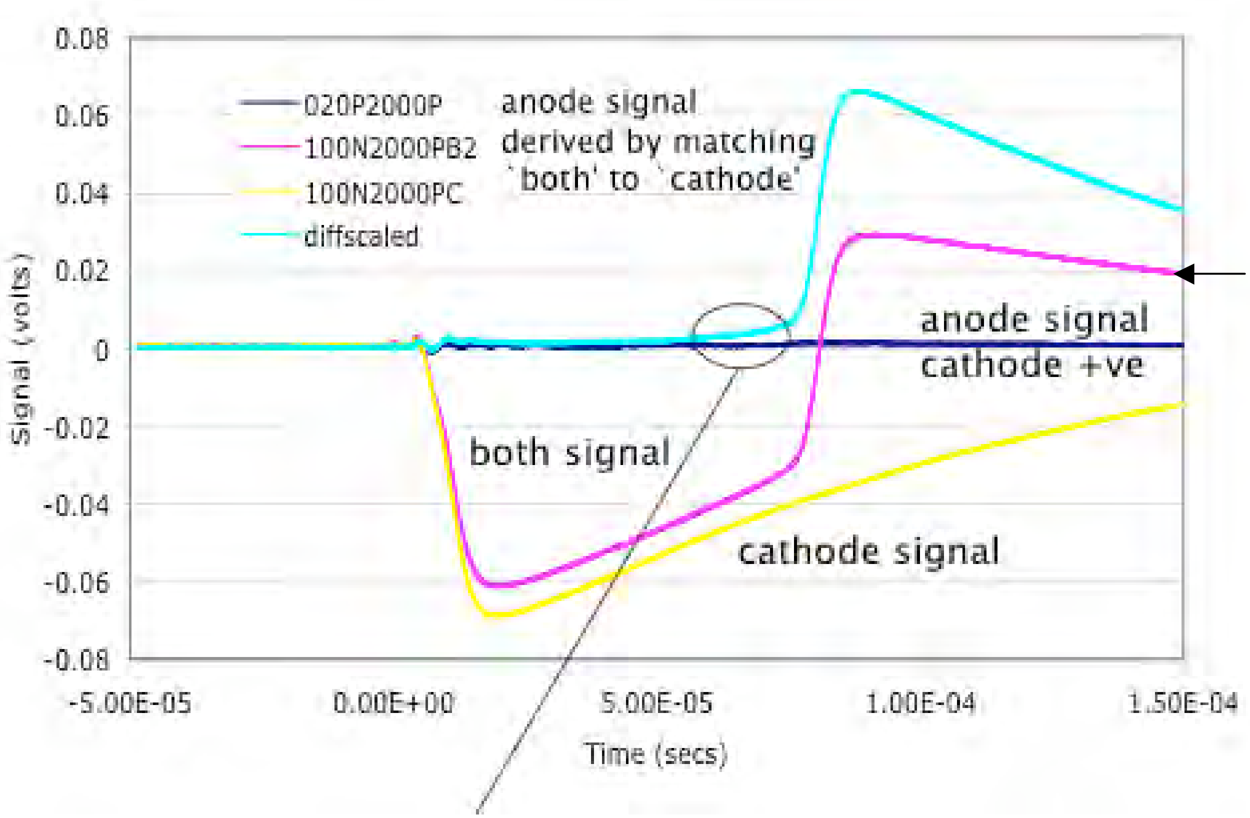
Liquid Argon setup at PAB

Argon purity studies



t_{drift}= 150 µs, $Q_{anode}/Q_{cathode}$= ~1

Diversion on why we look at cathode and anode individually

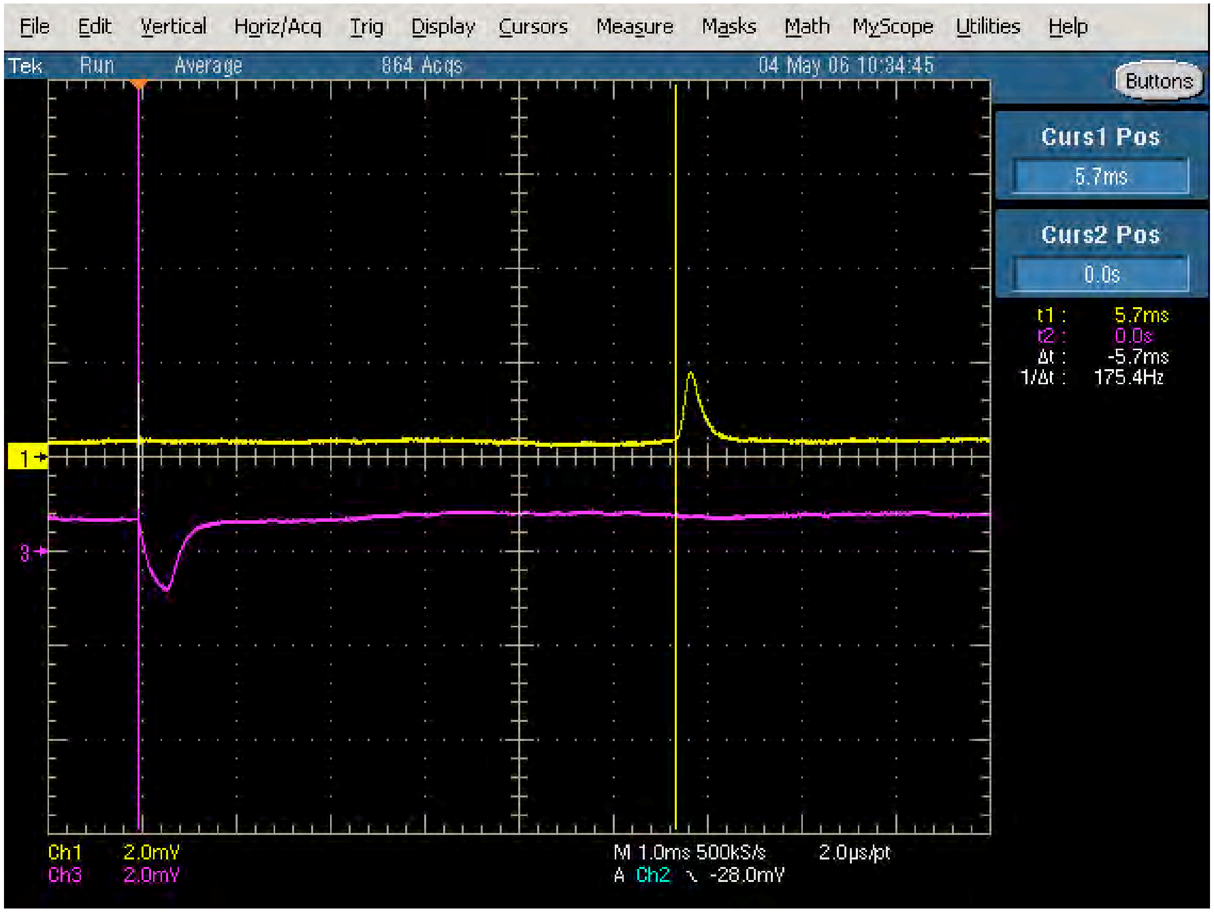


input into
ICARUS analysis

note precursor to main anode signal due to field of electrons leaking through the anode grid – (this depends on the grid structure)

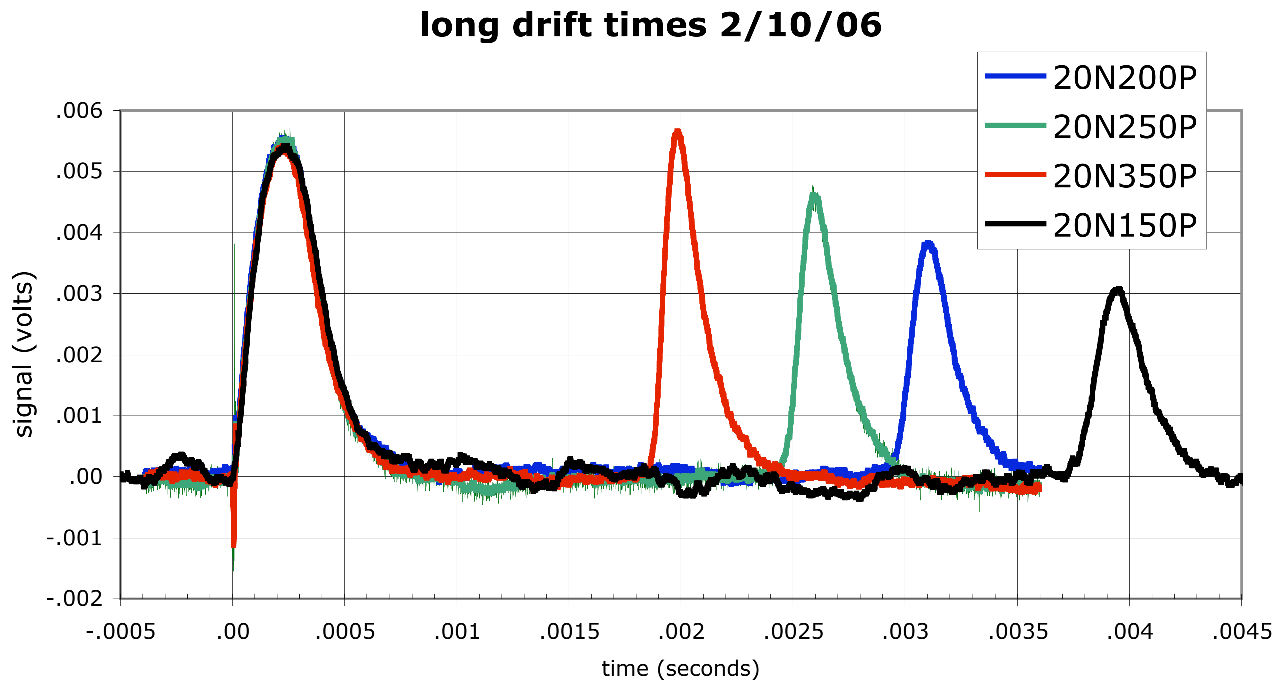
Lifetime Measurements:

a 5.7 millisecond drift with the long PrM



note that we look at the cathode and anode signals individually.

(ICARUS put both signals into a common amplifier)

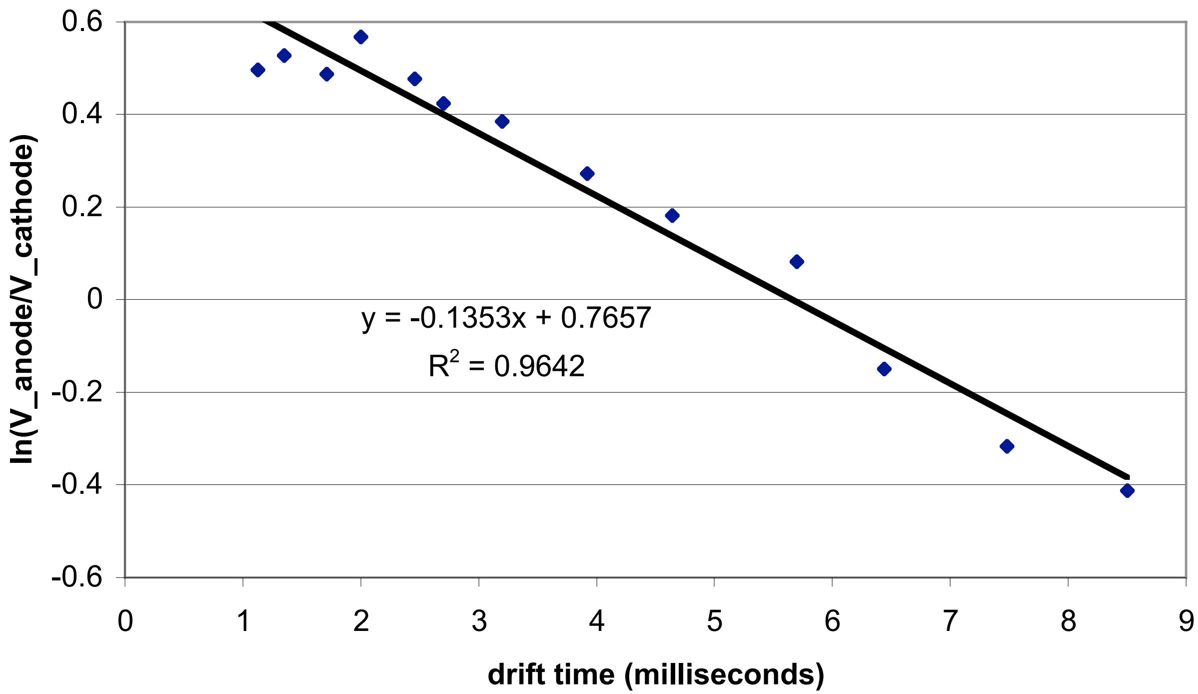


example of set of data used for lifetime measurement

Issues at present:

The decay time of the integrator, τ, is too short for long lifetimes....the peak of the cathode signal, in particular, is not a good measure of the charge... $Q_{true} / Q_{peak} = \tau/t \times (1- e^{-t/\tau})$ where t is the rise time of the cathode signal. ICARUS corrects for this. Our approach is to recognize that the correction is a constant for a fixed cathode field and to run a number of different drift fields that give the variation of the anode signal with drift time.

5/4/06 - 1 day after fill - lifetime = 7.4 milliseconds



typical plot used to obtain drift lifetime

each point comes from a different drift field setting

Issues continued.

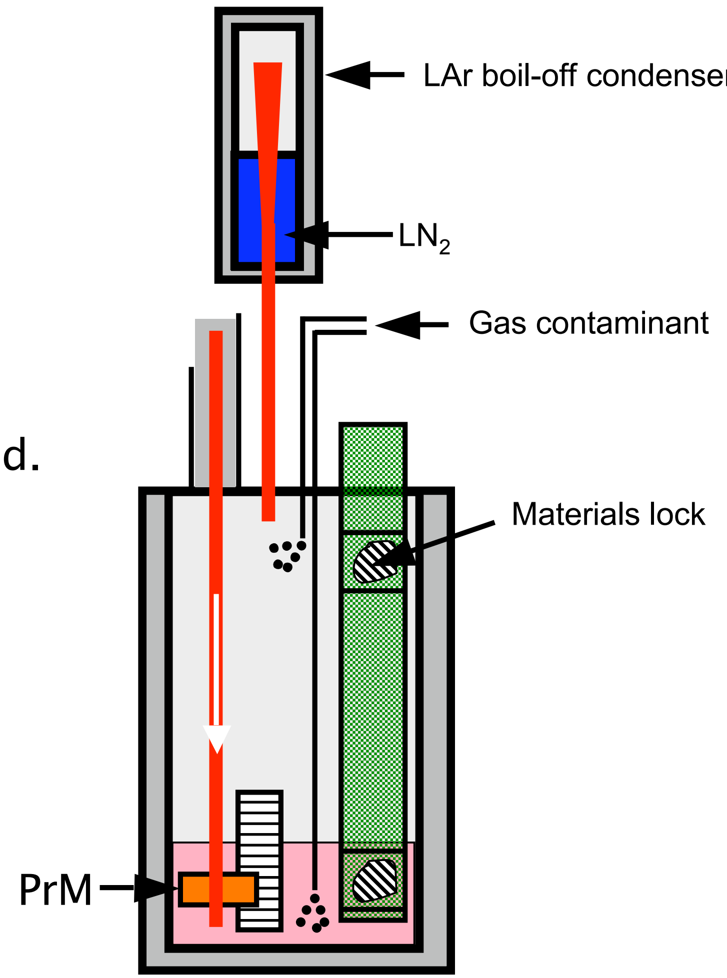
Whatever we do , to measure long drift-times requires low fields (~50 V/cm compared with the 500 V/cm we expect for TPC operation). The velocity of an 87K electron starts to increase with electric field at about 200 V/cm (Schmidt, in our docdb). This may affect the lifetime.

One contamination test we have tried..

We injected enough nitrogen (if it stayed in the liquid - we do not have a closed system) to generate 5 ppm in the liquid and saw no change in a few millisecond lifetime. This may not have been too surprising given that the Nitrogen spec. on the original Argon is <20 ppm and we do nothing explicit to remove it.

Next step in Purity Business:

Implement the Materials test station..
(new closed system cryostat - see right)
Developing in-cryostat thermal pump
Most of the parts for full system are on hand.
Start debugging the system by end of July.
Start testing materials October.



T. Tope